SECULAR CHANGES IN CLIMATE.

We are indebted to Mr James P. Hall of the editorial office of the New York Daily Tribune, for the following summary of the last two chapters of Ward's translation of Hann's Climatology. It presents the general impression that one obtains from reading Hann's summary of the recent condition of our knowledge of observations and theories bearing upon the periodic or the secular changes that the climate of any portion of the globe has experienced during recent centuries or past geological ages.

Mr. Hall says:

Dr. Hann is one of the world's leading authorities on atmospheric physics. He has summed up the work of other investigators more completely than anyone else. The second edition of his handbook is much more recent than the writings of Blodgett, Maury, Buchan, and Loomis. The value of the translation is distinctly enhanced by the notes of Professor Ward, himself a meteorologist of repute.

The suspicion that the climate of any country has permanently changed in so short an interval as one or two centuries is discouraged by Dr. Hann. He recognizes the existence of irregularities which sometimes show a disposition to fall into cycles, says that hasty conclusions have been drawn therefrom, but does not think the supposed chances well established as yet. Of the slow oscillations that have received the most attention, that running parallel with the 11-year sun-spot period is the first one mentioned. The Austrian cites some of the affirmations of Kœppen, Meldrum, and Lockyer regarding it, but concludes that most of the evidence which had come to him "is still too uncertain to show any actual relation between cause and effect." As most of Bigelow's work has been done since that opinion was expressed, the comment can hardly apply thereto. Brückner's observations, tending to show that there is a cycle in temperature and rainfall thirty-five years long, are viewed with favor. Dr. Hann thinks that he has "demonstrated the existence of the period with a high degree of probability."

That other climatic changes, far more extreme in degree and stretching through vastly longer periods, have really occurred on the globe is beyond question. Geology shows that in the Tertiary age vegetation such as is now found only in temperate latitudes flourished in the northern part of Alaska and Greenland and in Spitzbergen. Later a vast ice sheet from the Arctic reached away down in North America to the Ohio River and the south shore of Long Island. A large part of northern Europe was similarly covered. The snow line of the Alps was more than 4000 feet lower than now. Concerning the causes of the Glacial period, which is now believed to have been a series of intermittent visitations, there has been a vast amount of ingenious speculation. Practically all of the more striking hypotheses advanced to account for these changes are astronomical. Dr. Hann reviews several of the most important. He refrains from discussing the theory of Dubois, based on the probable fluctuations in the sun's thermal output, but mentions the inferences which have been drawn from the changes in the inclination of the earth's axis to the ecliptic, in the eccentricity of its orbit and the unequal length of the season.

The earth, it will be remembered, is some 3,000,000 miles nearer to the sun at one point in its orbit than on the opposite side. Just now it is there—at perihelion—during the winter of the Northern Hemisphere. The cold of that season results from the fact that the North Pole is tilted away from the sun. If, however, our winter came when the earth was at the greatest distance—at aphelion—the season would be much more severe, as well as longer. Owing to well known causes the position of the globe is slowly shifting, so that it works its way half way around the circle in ten thousand five hundred years, and gets back to the starting point in twenty-one thousand. Adhémar thought that a successior of aphelion winters would create such an accumulation of ice near the pole as to shift the earth's center of gravity, and lead to such a flow of water thither as to flood the continents partially. Schmick assumed that the latter effect might also result from an enhanced influence of the sun on the tides. Dr. Hann shows how little valid reason there is for accepting either of these notions.

Croll started with the same premises, but improved on the suggestions of his predecessors. The most novel feature of his theory was that during the long series of years in which the earth had aphelion winters the force of the northern trade winds would be increased, a larger amount of tropical water would be driven south of the equator than now, and the genial influence of the Gulf Stream on northern Europe would be diminished. Dr. Hann feels that climatology owes much to Croll for calling attention to factors previously overlooked, but he presents cogent reasons for not accepting that expert's theory. It is pointed out that it is the coast contour, rather than the trade winds, which chiefly controls the direction of the flow of equatorial water, while it is also held that severe cold in either hemisphere would not materially alter the strength of the trades. Though Sir Robert Ball professed to have treated the problem in a new way, Dr. Hann insists that his main argument had been advanced by others and is fallacious.

De Marchi cautiously suggests that if there were a trifling decrease in the case with which the air transmitted heat, inward from the sun and outward from the earth, an ice age in middle latitudes might ensue. He puts the requisite diminution at 10 per cent, or a decrease from a coefficient of 0.60 to one of 0. 54, but does not like to say what could thus diminish the thermal transparency of the atmosphere. Perhaps an increase or decrease in the amount of water vapor or carbon dioxide there might do it. Svante Arrhenius thinks that prior to the glacial period arctic warmth may have been due to an excess of carbon dioxide, liberated by volcanoes, while a reduction of the proportion would explain the temperatures of the ice age.

Dr. Hann holds that the simplest and most obvious explanation of secular changes in climate thousands, perhaps millions, of years ago would be the assumption that the position of the earth's axis had shifted. George H. Darwin, the astronomer and mathematician of Cambridge, says that the pole could not move more than 3° if the globe were rigid, but might get 10° or 15° away if it were plastic. Schiaparelli, at Milan, has reached a similar conclusion. Davis (of Harvard) has considered at length the probable effect of moving the North Pole down to latitude 70° in west longitude 20°. This change would glaciate northwestern Europe and northwestern (?) America. The question hinges, it will be seen, on the past plasticity of the globe. Despite the earth's present steel-like rigidity, Dr. Hann says that the past permanence of the pole has not been established. It is conceivable that geology may yet throw more light on this point.

A TERTIARY RAINBOW.

Mr. J. Neff Huyette, of Chicago, Ill., under date of May 16, 1903, writes as follows:

The forenoon of May 2, at Chicago, was clear, or very nearly so, up to about 11:30, at which hour the occasional light wisps of cirrus were replaced by very large masses of cirro-stratus, through some of which the sun shone but faintly. As the first of these passed over the sun a barely perceptible ring was seen, the lower portion of which, however, was quite brilliant. Just about halfway between the lowest part of this ring and the horizon I saw a bright streak, which I at first took to be a patch of cloud evolving into cirro-cumulus; but on looking a few moments later it was found to have assumed the most beautiful rainbow tints. I then looked overhead to see if there was a circle in that part of the heavens to correspond, but found none. This very beautiful sight lasted but a short time, beginning at 11:55 a. m. and ending at 12:03 p. m. The manner in which it disappeared was in keeping with the rest of this interesting sight: First some dark clouds passed gracefully over, after which the vision shone forth with increased beauty; then it appeared to move along to the east for a short distance, where it vanished. This latter occurrence seems to indicate that the cloud which caused the phenomenon covered but a comparatively small portion of the space within which this phenomenon could take place.

I may say, in closing, that I saw no curvature in the halo, and, with the exception of the fine coloring and brilliancy, there was nothing striking, as the halo itself was very ragged and broken.

I send you this account because it is the first time I have ever seen anything of this kind, and I have always kept a sharp lookout for this phenomenon, particularly since reading Mr. Warren's letter in the MONTHLY WEATHER REVIEW for June, 1902, page 317.

Do you not think the reason why this effect is so seldom observed is that in winter, when it is most likely to occur, it can not be seen unless one has a very free horizon?

On May 2 the sun's declination is about 15° north, consequently at noon of that date, in latitude 42 north, which is a little north of Chicago, the sun is between 62° and 63° above the horizon. As we understand the above description by Mr. Huyette, a ring surrounded the sun; halfway between the lowest and brilliant portion of this ring and the horizon there appeared a bright streak of rainbow tints without any curvature in the streak. The ring near the sun must have been of the nature of a corona, and is not likely to have been more than 5° from the sun. The rainbow arc, located halfway between the horizon and this corona, must, therefore, have been 29° above the horizon, or 34° below the sun. The only suggestion we have to make in explanation of this so-called halo is to call attention to the fact that the solar rays passing through a spherical drop of water will give rise to a number of halos, some of which are called rainbows, whose brilliancy and location depend upon the number of times that the beam of light is reflected within the drop. One reflection gives us the brilliant primary rainbow, whose angular distance from the sun is 138–140°. Two reflections give rise to the secondary rain-

bow of much feebler light, and whose distance from the sun is 126–130°. Three reflections within the drop give a rainbow whose radius is 41° from the sun. Four reflections give the quartenary rainbow whose radius is 44° from the sun. Five reflections give a halo whose radius is 126°. It is only under the most favorable circumstances that any fragments of the third and fourth rainbows can be seen owing to their faintness. Moreover, if the drops are not perfectly spherical these rainbows will appear in some other location than that just given. It does not seem likely that the bit of rainbow seen at Chicago on May 2 was due to reflection and refraction from crystals of ice, but rather from small drops of water, and that it was in fact a case of the visibility of the tertiary rainbow at 41° from the sun. This particular rainbow is not likely to occur in winter, but is then replaced by the various halos formed by ice crystals, as explained in the MONTHLY WEATHER REVIEW for July, 1897.

METEOROLOGY IN CHILE.

A recent letter from Mr. J. Munor Hustady, Director of the Meteorological and Magnetic services of the Bureau of Maritime Territory, Navy Department, Republic of Chile, informs us that the publication of the meteorological observations, taken by the various observatories established on the coast of that country, began with the volume for 1899, and that the two following years have also been published. These three volumes contain the original record of observations three times daily, at the following stations; mostly light-houses:

Station.	Latitude, south.	Longitude, west.	Altitude.
	°	°	*Meters.*
Iquique (Island of Serrano)	20	70	9
Caldera	27	70	23
Island of Chanaral	29	71	48
Tortuga (Coquimbo)	30	71	26
Anjeles (Valparaiso)	33	72	41
Juan Fernandez	34	79	10
Carranza	36	73	33
Tumbes	37	73	91
Santa Maria	37	73	65
Western Mocha	38	74	18
Eastern Mocha	38	74	32
Niebla	40	73	43
Galera	40	74	38
Ancud	42	74	48
The Evangelists	52	75	53
Dungeness	52	68	3

For these sixteen stations, substituting others if one is missing, the three volumes give the same data as far as practicable, viz: the full record day by day of pressure, temperature, wind, relative humidity, cloudiness, and rainfall, as also the monthly summaries of the same observations and, in some cases, of even more frequent observations; namely, the trihourly record for midnight, 3, 6, and 9 a. m., and noon, 3, 6, and 9 p. m., except only in the case of Dungeness for 1901. Unfortunately, serious errors occur in the observations of the light-house at Punta Carranza for 1899 and 1900, but the remaining records seem to be satisfactory. This is, we believe, the first time that complete daily records from South American stations have become accessible to meteorologists.

In addition to the above contribution by the navy, we note that the Astronomical Observatory at Santiago, founded in 1860, has published three volumes of its Annual. The Director, Prof. A. Obrecht, in the first volume of the Annuario, publishes a long memoir on the theory of lunisolar precession, followed by the determination of the latitude and longitude of the observatory, and another on the determination of the force of gravity; and there is a third memoir, by J. Taulis. The volume concludes with the chapter on the meteorology of Santiago de Chile, giving a general summary of the observations made since 1860, and also the monthly mean values, by A. Krahnass, who has had charge of the section of meteorology since October, 1891.

These three volumes form a continuation of the three issued in 1887, or earlier, by Señor I. Vergara, then director of the observatory.

The second volume begins with a photographic method for determining the movement of the terrestrial pole. This is followed by a discussion of the magnetic observations, and that by the table of geographic coordinates.—*C. A.*

EARTHQUAKES IN CALIFORNIA.

[Reported by Prof. A. G. McADIE.]

Although the subject of earthquakes belongs to geology rather than climatology, the Weather Bureau offices in the State of California have kept a record of shocks during the last few years, and published the results of 1897, 1898, 1899, and 1900 in the bulletin upon the climatology of the State. The Bureau records show that there is no relation between earthquakes and weather, although there is a well-defined belief among the older residents of California that earthquakes are preceded by a spell of sultry weather, and this is even known as "earthquake weather." Some of the most severe earthquakes have occurred when the conditions of weather were in nowise those which are said to be characteristic of quakes.

THE DURATION AND RATE OF RAINFALL.

In the Quarterly Journal of the Royal Meteorological Society, July, 1903, Mr. Joseph Baxendell discusses the records of rainfall obtained by self-registering gages at several stations in England.

At the Fernley Observatory, at Southport, a Halliwell gage was used by Mr. Baxendell himself. The total annual rainfall for 1902 was 25.42 in 199 days, or 640.1 hours, giving an annual mean of 0.0397 inch per hour.

At Croydon Mr. Baldwin Latham used the extensive self-recording gage of his own design, which gave 20.665 inches in 529.35 hours, or a mean annual rate of 0.0390, but this latter rate is abnormally low for Croydon, where the average for four years is 0.0650, for 1879–1882, and, again, 0.0574 for the four years 1898–1901. Mr. Latham also keeps in use one of Halliwell's gages, which furnishes records of equal accuracy.

Mr. Baxendell adds:

> The various self-recording rain gages hitherto in use, however, have unfortunately afforded little assistance in this direction, for most of them either (*a*) have their rims placed at a height of, at any rate, some feet above the ground, which, as instanced below, may vitiate the record of duration to a surprising extent, or (*b*) give "step-by-step" records, quite useless for this purpose, or (*c*) are designed to record on a far too contracted scale to render it practicable to deduce from their traces the duration of light rains with anything approximating to accuracy, while all are usually, in practise, more or less affected by friction and few contain any satisfactory provision for melting snow as it falls. The isolated annual durations of rainfall that are published frequently differ 10 per cent from the truth.

In illustration of this last statement, Baxendell quotes a comparison between gages, some of which appear to have less friction than others, while some are higher than others. It is not quite evident that any gage can give us the absolute truth as compared with hourly personal observations by a large corps of observers.—*C. A.*

THE CAPACITY OF THE AIR FOR AQUEOUS VAPOR.

The Editor frequently has occasion to revise or "edit" the manuscript that is sent him for publication. It follows that he sometimes becomes painfully conscious of the extent to which erroneous views are still held by some of the best men in the service. As one of the fundamental objects of the MONTHLY WEATHER REVIEW is the dissemination of sound views in meteorology and the general education of both regular and